METHOD FOR INCREASING THE EFFICIENCY OF DIESEL-ELECTRIC DRIVEN VEHICLES, AND VEHICLE FOR CARRYING OUT THE METHOD

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Abstract
In a method for increasing the efficiency of a consist comprised of a plurality of linked diesel-electric driven vehicles, with each vehicle including a diesel assembly and an intermediate circuit which is operatively connected to the diesel assembly and a drive motor which is operatively connected to the intermediate circuit, the operation of the diesel assembly of a vehicle is deactivated, when the vehicle requires a reduced level of power, while the vehicle is in travel mode. The drive motor is hereby operated in a regenerative mode and solely responsible, when operating in the regenerative mode, to feed electric energy to the intermediate circuit of the deactivated diesel assembly and an auxiliary operating device, connected to the intermediate circuit.
METHOD FOR INCREASING THE EFFICIENCY OF DIESEL-ELECTRIC DRIVEN VEHICLES, AND VEHICLE FOR CARRYING OUT THE METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority of German Patent Application, Serial No. 10 2006 042 945.1, filed Sep. 13, 2006, pursuant to 35 U.S.C. 119(a)-(d), the content of which is incorporated herein by reference in its entirety as if fully set forth herein.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a method and apparatus for increasing the efficiency of a consist comprised of a plurality of diesel-electric driven vehicles.

[0003] Nothing in the following discussion of the state of the art is to be construed as an admission of prior art.

[0004] Freight trains are often operated with multiple traction, i.e. a freight train is driven by a number of diesel locomotives. Depending on the acceleration behavior and terrain to be negotiated, the diesel drives of the diesel locomotives are hereby not operated at full power at all times. However, operating a diesel assembly in partial load range adversely affects efficiency.

[0005] When freight trains are operated with multiple traction, the diesel locomotives are normally used with one large diesel engine per locomotive without control or voltage connections between the locomotives. In other words, even when the power demand is relatively low, such as for example when traveling downhill for an extended period, the diesel assemblies of each locomotive have to be kept operational in order to provide sufficient energy, for example in order to operate the brake system of the locomotive.

[0006] The publication “Intelligent Power Sharing within a Locomotive Consist for Fuel Reduction and Trip Reliability Enhancements” (Gritschi et al., Heavy Haul Conference, Brazil, 2005), discloses the linkage of a plurality of diesel locomotives with an electric drive to realize a consist in which the intermediate circuits of all the locomotives are connected to one another. Connecting the intermediate circuits of all the locomotives to one another makes it possible to transfer the electric power produced at one locomotive to another locomotive and thus to feed the required power from a small number of diesel assemblies into the overall intermediate circuit and switch off the remaining diesel assemblies. In other words, when a relatively low level of power is required, a number of diesel locomotives travel with activated diesel assemblies and other diesel locomotives travel with deactivated diesel assemblies, whereby the required energy of one locomotive with the deactivated diesel assembly is transferred from locomotives with activated diesel assemblies to locomotives with deactivated diesel assemblies to maintain the auxiliary operations, for example the brake systems and the temperature maintenance of the diesel assemblies. At the same time, the full starting tractive force is maintained since all the drives of each locomotive can also be provided with power by virtue of the connection of the intermediate circuits, and therefore all the drives can also be active during starting. Diesels which are deactivated in the travel mode can optionally be started up again by means of a converter or its intermediate circuit. However, high voltage coupling points in the region of the locomotive couplings have to be provided in order to be able to connect the intermediate circuits of the locomotives to one another. These high voltage lines usually conduct a voltage of approximately 2000 volts, which has to be isolated for safety reasons when the coupling point is not used. The connection of the intermediate circuits complicates the overall construction and requires appropriate safety measures.

[0007] It would therefore be desirable and advantageous to address this problem and to obviate other prior art shortcomings.

SUMMARY OF THE INVENTION

[0008] According to one aspect of the present invention, a method for increasing the efficiency of a consist comprised of a plurality of linked diesel-electric driven vehicles, with each vehicle including a diesel assembly and an intermediate circuit which is operatively connected to the diesel assembly and a drive motor which is operatively connected to the intermediate circuit, includes the steps of deactivating operation of the diesel assembly of a vehicle, when the vehicle requires a reduced level of power, while the vehicle is in travel mode, operating the drive motor in a regenerative mode, and feeding electric energy to the intermediate circuit of the deactivated diesel assembly and an auxiliary operating device, connected to the intermediate circuit, solely by the drive motor, as it operates in the regenerative mode.

[0009] In the normal travel mode, when the diesel assembly is activated, the main generator of the locomotive which is connected downstream of the diesel assembly in order to generate electric energy feeds the auxiliary operating devices which are connected to an intermediate circuit. In the travel mode, on the other hand, when the diesel assembly is deactivated, the drive motors can be operated as generators and thus feed the intermediate circuit. The thus-produced energy can be used to restart the diesel engine and to maintain the operating temperature and to supply power to individual, relatively small consumers such as, for example, pumps, fans or lighting systems. As a result, efficiency of diesel drives of a plurality of vehicles traveling with multiple traction can be increased, and, when a specific reduced level of power is required of the vehicles which are traveling in a consist, at least one diesel assembly of one of the vehicles is deactivated. The power for maintaining the auxiliary operations and for restarting the diesel assemblies can thus be transmitted indirectly from one locomotive to another locomotive by converting the mechanical energy of the wheels and the regeneratively operating drive motors.

[0010] In accordance with the invention, it is thus possible to switch off the diesel assembly when n vehicles (multiple traction) are operating and there is a request for a reduced locomotive power of up to n−1 vehicles. The regenerative operation of the drive motors allows the auxiliary operations to be provided with electric energy on the vehicle with the diesel assembly deactivated. The possibility of deactivating individual diesel assemblies while maintaining the full driving power results in cost saving and reduces wear of the diesel assemblies since a diesel assembly can be switched off, when the power demand is low, and does not have to be operated in the unfavorable partial load range. As a result, fuel consumption can also be reduced.
[0011] According to another feature of the present invention, the diesel assembly can be deactivated automatically when the level of power reaches a lower limit. In other words, when the power drops below a specific value, the associated diesel assembly switches off automatically. Suitably, the diesel assembly switches on again automatically, when the lower power limit is exceeded again.

[0012] According to another feature of the present invention, the drive motor may provide electric energy that is commensurate with a power demand consumed by the auxiliary operating device. When, for example, the external temperature is high, less energy is necessary to maintain a specific operating temperature of the diesel assemblies. Suitably, the regeneratively operating drive motors produces correspondingly less power to maintain the operating temperature. As a result of this configuration, the regeneratively operating drive motors have a reduced braking effect, which leads to a further increase in efficiency during operation of the vehicle and in the case of multiple traction.

[0013] According to another feature of the present invention, the method steps can be realized under the control of a control unit. Thus, the fully automated deactivation and restarting of the diesel assemblies in response to the power demand, as well as the control of the drives can be executed in a controlled manner such that only energy is supplied as is necessary to maintain the auxiliary operations and the operating temperature of the diesel assembly.

[0014] According to another aspect of the present invention, a vehicle includes at least one diesel assembly, a generator connected to the diesel assembly for feeding electric energy to an intermediate circuit, at least one converter coupled to the intermediate circuit, at least one auxiliary operating device coupled to the intermediate circuit, and a drive motor receiving electric energy from the converter and constructed for operation in a motor mode and regenerative mode, wherein the drive motor operates in the regenerative mode, when the diesel assembly is deactivated while the vehicle is in travel mode, so that the intermediate circuit and the auxiliary operating device are fed exclusively by the drive motor with electric energy.

[0015] As already described above, the regenerative mode of the drive motor is the operating mode as a generator. When operating as a generator, the drive motor feeds electric energy into the respective intermediate circuit. This electric energy is used in the intermediate circuit to restart the diesel assembly and to maintain the desired operating temperature of the diesel assembly for restarting, as well as to maintain specific auxiliary operations. Since the mechanical energy of the wheels is converted into electrical energy, when the vehicle travels with the diesel assembly deactivated, the electrical energy which is generated by a locomotive in multiple traction mode can be converted into mechanical energy and supplied to another locomotive by virtue of the conversion of the mechanical energy into electrical energy.

[0016] The converter may be implemented as a pulse-controlled inverter, i.e. an active rectifier. Suitably, at least one inverter, which feeds at least one drive motor, may be connected in the intermediate circuit. It is thus possible, to deactivate n-1 locomotives or their diesel assemblies, when multiple traction is involved and a reduced level of traction power is required by n vehicles which are each equipped with a diesel assembly. The supply to the auxiliary operations on the other vehicles is maintained by the regenerative operation of the drives.

[0017] According to another feature of the present invention, a control level may be provided having at least one connection for connecting the control level to a control level of a further vehicle in the absence of a high voltage connection of the intermediate circuit to an intermediate circuit of the further vehicle. By means of the control level with its connecting points, it is possible for at least one diesel assembly on a specific vehicle to be activated or deactivated or switched to a standby mode. In this context, it is possible for the diesel assembly of a specific locomotive to be switched off or on from a central location with overall control of the locomotives. There is no need to connect high voltage lines of the locomotives to one another because the power supply for the auxiliary operations and for restarting the diesel assembly is provided in the travel mode of the deactivated locomotive by means of the regenerative operation of its drive motors. As the high voltage lines of the locomotives are not connected to one another, there are also no coupling points for producing such connections. In other words, conventional mechanical couplings can be provided between the locomotives, and connections of low voltage lines can be used for operating relatively small assemblies such as, for example, fans, pumps and lighting devices and possibly couplings of pressure lines, without the need for coupling points for the high voltage line of an intermediate circuit for connecting the intermediate circuit to the intermediate circuit of another locomotive.

[0018] The intermediate circuit of each diesel assembly of a locomotive thus does not have branches. The elimination of a high voltage connection removes also the need for costly isolation of approximately 2000 volts which would be required, when the assembly is not in use, and necessary for safety reasons, so that the structural design of the vehicle is simplified.

[0019] According to another feature of the present invention, a control unit may be provided for switching the diesel assembly on or off via the control level in dependence on the power demand, and for controlling the drive motor in the regenerative mode such that the drive motor provides only power that is commensurate with a need by the auxiliary operating devices. In other words, the control unit manages the deactivation and restarting of the diesel engines in the case of a corresponding power demand, as well as the control of the drives, in such a way that they only supply as much energy as is necessary to maintain the auxiliary operations and the operating temperature of the diesel assembly and to restart the diesel assembly. The control unit can influence the assemblies of any of the locomotives which are traveling in consist or can control them by connecting the control levels of vehicles which travel in multiple traction.

[0020] According to another feature of the present invention, two diesel assemblies may be provided, wherein the generators of the diesel assemblies jointly feed a common intermediate circuit. This double arrangement of diesel assemblies on one vehicle allows that one of the two diesel engines can be deactivated or operate in a standby mode (in particular when a reduced level of power is required), and, when the power demand drops even further, a second diesel
engine can also be deactivated. As a result of the regenerative operating mode of the drive motors, both diesel engines whose intermediate circuits are independent of one another can be started again by means of their regeneratively operating drive motors, or their auxiliary operating devices are fed by the regeneratively operating drive motors. It is thus possible to provide, in a vehicle which is provided with two diesel assemblies, that when the intermediate circuits of the diesel assemblies are disconnected entirely, the power supply of one auxiliary circuit of one deactivated diesel assembly is provided exclusively by means of the conversion of the mechanical energy of the wheels into electrical energy in order to feed the intermediate circuit when the diesel assembly is deactivated.

[0021] According to another feature of the present invention, two inverters may be arranged at the intermediate circuit, with each of the inverters feeding up to three drive motors on one bogie. Thus, for example, each of the inverters may feed three drive motors which are arranged on one bogie. As a result, even when just one diesel assembly is operating, voltage is available for operating both drive converters and all the motors can supply the full starting torque. At startup, just one diesel assembly is required to operate, either on a locomotive with a plurality of diesel assemblies or in a consist of vehicles operating in multiple traction in which individual locomotives or their diesel assemblies are deactivated.

[0022] According to another feature of the present invention, the generator of the vehicle may be configured for operation in motor mode as a starter of the diesel assembly. As a result, the intermediate circuit which is fed via the regeneratively operating drive motors supplies the power for starting the diesel assembly by means of the vehicle’s generator which is operated as a starter. For this purpose, the generator may have an active rectifier.

[0023] The rectifier which is connected downstream of the generator in the normal travel mode may serve as a pulse-controlled inverter for the generator which functions as a starter.

[0024] According to another feature of the present invention, there may be provided a battery, and a DC/DC converter which connects the battery to the intermediate circuit. As a result, when no energy is stored in the intermediate circuit as of yet during initial startup of the diesel locomotive, the diesel locomotive can be started by the electric energy from the battery via the DC/DC converter and the generator which functions as a starter. The DC/DC converter can be configured in such a way that it can be used as a battery charging device in the normal travel mode.

[0025] According to another feature of the present invention, the auxiliary operating device may include an auxiliary operating converter and a pulse-controlled inverter which is configured for driving the generator which functions as the starter of the diesel assembly. The auxiliary operating converter is used when supplying power to the auxiliary operating devices.

[0026] According to another feature of the present invention, the generator of the vehicle may be configured as a permanently excited synchronous machine. This enables efficient operation of the vehicle in a simple manner.

BRIEF DESCRIPTION OF THE DRAWING

[0027] Other features and advantages of the present invention will be more readily apparent upon reading the following description of currently preferred exemplified embodiments of the invention with reference to the accompanying drawings, in which the sole FIGURE shows a schematic illustration of a consist with three diesel-electric driven locomotives operated with multiple traction.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0028] The depicted embodiment is to be understood as illustrative of the invention and not as limiting in any way. It should also be understood that the FIGURE is not necessarily to scale and details which are not necessary for an understanding of the present invention or which render other details difficult to perceive may have been omitted.

[0029] Turning now to the FIGURE, there is shown a consist with vehicles 1 in the form of three diesel-electric driven locomotives which are coupled to one another mechanically. Each of the vehicles 1 has a diesel assembly 2 as well as a generator 3, a converter 4, an auxiliary operating device 5, and a plurality of drive motors 6 which are arranged on bogie 9. One of the vehicles 1 is equipped with a control unit 7, which is connected to the control level 8 of the vehicle 1. The control level 8 is connected in series with the control levels 8 of the further vehicles 1.

[0030] Furthermore, each of the vehicles 1 has an auxiliary operating converter 10 and a heating resistor 11. The heating resistor 11 serves to maintain the operating temperature of the diesel assembly 2 when power is supplied.

[0031] When reduced power levels are required in travel mode, the control unit 7 is able to transmit, via the control levels 8, a signal to the diesel assembly 2, for example of the middle vehicle 1, so that this diesel assembly 2 is deactivated. The electric drives 6 which are arranged on the bogie 9 are no longer supplied with electric energy from this moment on and they no longer drive the wheels of the vehicle 1. However, as a result of the fixed mechanical connection of the wheels of the vehicle 1 to the drive motors 6, the rotational parts of the drive motors 6 are still moving and thus operate in a generator mode of the drive motor 6. The electric energy generated in the generator mode is fed into an intermediate circuit 2a of the vehicle 1. Only the intermediate circuit 2a of the middle vehicle 2 is shown here schematically, by way of example, for the sake of simplicity. The auxiliary operating device 5 is supplied with energy via the auxiliary operating converter 10 to feed, for example, the heating resistor 11 of the vehicle 1 in order to maintain the desired operating temperature of the diesel assembly 2. However, it is also possible to feed the heating resistor 11 with electric energy directly via the intermediate circuit 2a which is connected to the heating resistor 11.

[0032] At startup of the diesel assembly 2, the energy which is stored in the intermediate circuit 2a is fed to the generator 3 which functions as a starter in this case. Thus, the vehicle 1 can be restarted by the energy generated by the drive motors 6, while the vehicle 1 with deactivated diesel assembly 2 travels.

[0033] As a result, there is no need for a connection of the high voltage regions or of the intermediate circuits 2a of the
vehicle 1 to the intermediate circuits 2a of connected vehicles 1 since the electric energy which is necessary to restart or to maintain the auxiliary operations is acquired from the mechanical energy which is present in the travel mode and is converted. Therefore, there is also no need for coupling points for high voltage systems to be arranged in the mechanical coupling region of the vehicles 1.

[0034] While the invention has been illustrated and described in connection with currently preferred embodiments shown and described in detail, it is not intended to be limited to the details shown since various modifications and structural changes may be made without departing in any way from the spirit of the present invention. The embodiments were chosen and described in order to best explain the principles of the invention and practical application to thereby enable a person skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims and includes equivalents of the elements recited therein:

1. A method for increasing the efficiency of a control comprised of a plurality of linked diesel-electric driven vehicles, each vehicle including a diesel assembly and an intermediate circuit which is operatively connected to the diesel assembly and a drive motor which is operatively connected to the intermediate circuit, said method comprising the steps of:
   a) deactivating operation of the diesel assembly of a vehicle, when the vehicle requires a reduced level of power, while the vehicle is in travel mode;
   b) operating the drive motor in a regenerative mode;
   c) feeding electric energy to the intermediate circuit of the deactivated diesel assembly and an auxiliary operating device, connected to the intermediate circuit, solely by the drive motor, as it operates in the regenerative mode.

2. The method of claim 1, wherein the diesel assembly is deactivated automatically when the level of power reaches a lower limit.

3. The method of claim 1, wherein the drive motor provides electric energy that is commensurate with a power demand consumed by the auxiliary operating device.

4. The method of claim 1, further comprising the step of using a control unit for a realizing a controlled operation of steps a) to c).

5. A vehicle, comprising:
   at least one diesel assembly;
   a generator connected to the diesel assembly for feeding electric energy to an intermediate circuit;
   at least one converter coupled to the intermediate circuit;
   at least one auxiliary operating device coupled to the intermediate circuit, and
   a drive motor receiving electric energy from the converter and constructed for operation in a motor mode and regenerative mode, wherein the drive motor operates in the regenerative mode, when the diesel assembly is deactivated while the vehicle is in travel mode, so that the intermediate circuit and the auxiliary operating device are fed exclusively by the drive motor with electric energy.

6. The vehicle of claim 5, further comprising a control level with at least one connection for connecting the control level to a control level of a further said vehicle in the absence of a high voltage connection of the intermediate circuit to an intermediate circuit of the further vehicle.

7. The vehicle of claim 6, further comprising a control unit for switching the diesel assembly on or off via the control level in dependence on the power demand, and for controlling the drive motor in the regenerative mode such that the drive motor provides only power that is commensurate with a need by the auxiliary operating devices.

8. The vehicle of claim 5, further comprising two of said diesel assembly, wherein the generators of the diesel assemblies jointly feed the intermediate circuit with is common to both diesel assemblies.

9. The vehicle of claim 5, further comprising two inverters arranged at the intermediate circuit, wherein each of the inverters feeds up to three drive motors on a bogie.

10. The vehicle of claim 5, wherein the generator is configured for operation in motor mode as a starter of the diesel assembly.

11. The vehicle of claim 10, further comprising a rectifier connected downstream of the generator in normal travel mode and serving as a pulse-controlled inverter for the generator which functions as the starter of the diesel assembly.

12. The vehicle of claim 5, further comprising a battery, and a DC/DC converter which connects the battery to the intermediate circuit.

13. The vehicle of claim 12, wherein the DC/DC converter is configured for use as a battery charging device in normal travel mode.

14. The vehicle of claim 10, wherein the auxiliary operating device includes an auxiliary operating converter and a pulse-controlled inverter which is configured for driving the generator which functions as the starter of the diesel assembly.

15. The vehicle of claim 5, wherein the generator is a permanently excited synchronous machine.

16. A consist, comprising a plurality of track-bound vehicles which are coupled to one another, each said vehicle supported for mobility on the track by a bogie, a diesel assembly, and a drive motor mounted in the bogie and operatively connected to the diesel assembly via an intermediate circuit, said drive motor being constructed for operation in a motor mode, in which the diesel assembly is operative so that the intermediate circuit is supplied with electric energy from a generator connected to the diesel assembly, and a regenerative mode, in which the diesel assembly is deactivated and the intermediate circuit is supplied with electric energy solely from the drive motor during movement of the bogie.